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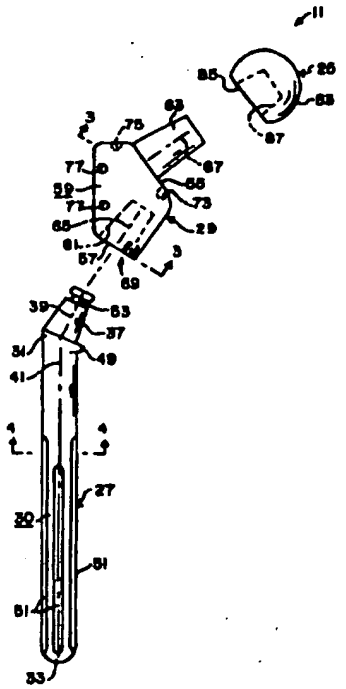
(54) Title: A MODULAR HUMERAL PROSTHESIS, AND MODULAR INSTRUMENTATION FOR PREPARING A HUMERUS FOR SAME, AND A METHOD FOR IMPLANTING SAME

(57) Abstract

The present invention is a modular humeral prosthesis (11) for replacing at least a portion of the articulating surface of a proximal humerus (15) of a shoulder joint. The prosthesis (11) includes a stem module (27) for insertion into the proximal humerus (15), and an intermediate module (29) for adjustable attachment to the stem module (27). Modular instrumentation is provided for preparing the proximal humerus for the prosthesis. The instrumentation (111) includes a stem module (113) for extending into a medullary cavity in the proximal humerus (15), one or more rasp modules (115) for adjustable attachment to the stem module (113), and for preparing an enlarged mouth in the medullary cavity in the proximal humerus (15).



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SPECIFICATION

A MODULAR HUMERAL PROSTHESIS, AND MODULAR INSTRUMENTATION FOR PREPARING A HUMERUS FOR SAME, AND A METHOD FOR IMPLANTING SAME

BACKGROUND OF THE INVENTION

The present invention relates generally to shoulder joint prostheses and more specifically to a modular humeral prosthesis with adjustable version, modular instrumentation for preparing a humerus to receive the modular humeral prosthesis, and a method of implanting the modular humeral prosthesis.

Shoulder joints are often repaired and reconstructed using prosthetic components that replace certain portions of the shoulder joint. A shoulder joint prosthetic system includes a humeral prosthesis for replacing at least a portion of the proximal end of the body of a humerus, and may include a glenoid or scapular prosthesis for replacing at least a portion of the articulating surface of a scapular, etc.

A typical humeral prosthesis includes a head for replacing at least a portion of the rounded head of the proximal end of a humerus and for articulating with the glenoid fossa of the scapula (or with a glenoid or scapular prosthesis), and a stem for extending into a medullary cavity or bore formed in the upper extremity or proximal end of the humerus.

The head and stem of a humeral prosthesis may be made integral with one another to form a one-piece, integral prosthesis. Representative one-piece, integral humeral prostheses are disclosed in Scales et al., U.S. Patent No. 3,694,820, issued October 3, 1972; Golyakhovsky, U.S. Patent No. 3,803,641, issued April 16,

1974; Stroot, U.S. No. Patent 4,045,825, issued September 6, 1977; and Scales, U.S. Patent 4,106,130, issued August 15, 1978.

Alternatively, the head and stem of a humeral prosthesis may be designed as separate components to allow different sized heads to be placed onto a stem which has been implanted in a proximal humerus. Dines et al., U.S. Patent No. 4,865,605, issued September 12, 1989; and Dale et al., U.S. Patent No. 4,919,670, issued April 24, 1990 are representative of such humeral prostheses having separate heads and stems.

Such prior art humeral prostheses can be manufactured in various sizes in an attempt to accommodate the differences between individual patients and can be custom made for a particular patient based on pre-surgery X-rays or the like.

U.S. Patent No. 5,002,581 to Paxson et al. discloses a hip joint prosthesis comprising a head portion, an intermediate trochanteral portion and a stem portion. The trochanteral portion is characterized by an extending flange for resting on the proximal femur, and by a complex geometry specially adapted for placement within the canal of the femur. Such a formation is unsuitable for use as a humeral prosthesis.

Nothing in the known prior art discloses or suggests the present invention. More specifically, nothing in the known prior art discloses or suggests a modular humeral prosthesis including separate head and stem modules and a separate intermediate or neck module for adjustably joining the head and stem modules together, the intermediate module having a circular cross section flaring outwardly towards the proximal end to form a generally oval cross-section at the distal end thereof, modular instrumentation preparing a humerus to receive

such a modular humeral prosthesis, and/or a method for implanting such a modular humeral prosthesis that allows a surgeon to prepare a medullary cavity in the proximal humerus for receiving the prosthesis that has an optimum size and shape based on the patient's bone structure, etc., and then to configure the prosthesis to closely match that medullary cavity.

SUMMARY OF THE INVENTION

The present invention provides a modular humeral prosthesis including separate head and stem modules and a separate intermediate or neck module for adjustably joining the head and stem modules to one another, modular instrumentation preparing a humerus to receive such a modular humeral prosthesis, and a method for implanting such a modular humeral prosthesis.

A basic concept of the present invention is to provide such a prosthesis, modular instrumentation and method that allows a surgeon to prepare a medullary cavity in the proximal humerus having an optimal shape and size depending on the patient's bone structure, etc., to then note the overall shape and size of the medullary cavity thus prepared, and then to configure or adjust the prosthesis to closely match that noted overall shape and size.

The typical surgical procedure for implanting a humeral prosthesis includes first resecting or otherwise removing the head from the upper extremity of the humerus, generally along the anatomical neck of the humerus. Next, the surgeon reams or otherwise prepares a bore or medullary cavity substantially along the longitudinal axis of the proximal humerus by first inserting a starter reamer or broach into the upper extremity of the proximal humerus. The surgeon may then sequentially enlarge the medullary cavity using reamers or broaches of progressively increasing sizes until the

surgeon is satisfied with the medullary cavity thus prepared in the proximal humerus. The surgeon may then use a rasp or the like to enlarge the mouth of the medullary canal by removing cancellous bone adjacent the mouth of the medullary canal, generally within an enlarged area of the proximal humerus between the anatomical and surgical necks.

The medullary cavity thus prepared in the proximal humerus has a mouth opening or proximal portion generally adjacent the tuberosities and between the anatomical and surgical necks of the proximal humerus, and a shaft or distal portion extending distally from the mouth or proximal portion. The mouth or proximal portion generally has a somewhat oval cross-sectional shape while the shaft or distal portion generally has a substantially circular cross sectional shape. Because of variations in bone structure, etc., a properly prepared bore in the proximal humerus of some patients may have a relatively small distal portion and a relative large proximal or mouth portion or vice versa, etc. Likewise, the relative rotation or version between the distal portion and the proximal or mouth portion can vary from patient to patient from a neutral angle to acute retroversion or anteversion as will now be apparent to those skilled in the art. In any event, once the surgeon is satisfied with the medullary cavity in the proximal humerus, a humeral prosthesis that best fits the medullary cavity, etc., is selected and implanted in a well-known manner using bone cement or the like. While it is best for the surgeon to be guided primarily by the patient's existing bone structure in preparing the medullary cavity in the proximal humerus, the medullary cavity must also be sized and shaped so as to accommodate available humeral prosthesis.

The present invention allows the surgeon to prepare a patient's humerus based on the patient's bone structure

and then select and configure the proper size and shape humeral prosthesis from separate head, stem and intermediate or neck modules, etc.

One object of the present invention is to provide a humeral prosthesis that has both separate head and stem modules and a separate intermediate or neck module joining the head and stem modules so that the surgeon can select individual modules that best fit the medullary cavity and can rotate the individual modules relative to one another to best accommodate the version between the shaft or distal portion of the medullary cavity and the mouth or proximal portion of the medullary cavity, etc.

Another object of the present invention is to provide a modular humeral prosthesis that allows the original center of a humeral head to be restored or duplicated, including offset and neck length.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded side elevation view of a first preferred embodiment of the modular humeral prosthesis of the present invention.

Fig. 2 is a side elevation view of the modular humeral prosthesis of Fig. 1 shown implanted in a shoulder joint.

Fig. 3 is a sectional view substantially as taken on line 3-3 of Fig. 1 on a somewhat enlarged scale and with portions omitted for clarity.

Fig. 4 is a sectional view substantially as taken on line 4-4 of Fig. 1 on a somewhat enlarged scale and with portions omitted for clarity.

Fig. 5 is a front elevation view of a portion of the

modular humeral prosthesis of Fig. 1, showing a first degree of version.

Fig. 6 is a front elevation view of a portion of the modular humeral prosthesis of Fig. 1, similar to Fig. 5 but showing a second degree of version.

Fig. 7 is a front elevation view of a portion of the modular humeral prosthesis of Fig. 1, similar to Figs. 5 and 6 but showing a third degree of version.

Fig. 8 is an exploded side elevation view of a first preferred embodiment of certain modular instrumentation of the present invention for preparing a humerus to receive the modular humeral prosthesis of the present invention.

Fig. 9 is a somewhat diagrammatic sectional view of a shoulder joint before being prepared to receive the modular humeral prosthesis of the present invention.

Fig. 10 is a somewhat diagrammatic view showing the modular instrumentation of Fig. 8 being used to prepare a humerus to receive the modular humeral prosthesis of the present invention.

Fig. 11 is a view of the modular instrumentation of Fig. 8 shown in combination with a humerus after the humerus has been prepared with the modular instrumentation to receive the modular humeral prosthesis of the present invention but before the modular instrumentation has been removed from the prepared humerus.

Fig. 12 is a sectional view substantially as taken on line 12-12 of Fig. 11, showing a first degree of version.

Fig. 13 is a sectional view similar to Fig. 12 but showing a second degree of version.

Fig. 14 is a sectional view similar to Figs. 12 and 13 but showing a third degree of version.

Fig. 15 is an exploded side elevation view of a second preferred embodiment of the modular humeral prosthesis of the present invention.

Fig. 16 is a sectional view substantially as taken on line 16-16 of Fig. 15.

Fig. 17 is a sectional view substantially as taken on line 17-17 of Fig. 15.

Fig. 18 is a sectional view substantially as taken on line 18-18 of Fig. 15.

Fig. 19 is an exploded side elevation view of a third preferred embodiment of the modular humeral prosthesis of the present invention.

Fig. 20 is a sectional view substantially as taken on line 20-20 of Fig. 19.

Fig. 21 is a sectional view substantially as taken on line 21-21 of Fig. 19 with portions omitted for clarity.

Fig. 22 is an exploded side elevation view of a third preferred embodiment of the modular humeral prosthesis of the present invention.

Fig. 23 is a sectional view substantially as taken on line 23-23 of Fig. 22 with portions omitted for clarity.

Fig. 24 is a sectional view substantially as taken on line 24-24 of Fig. 22 with portions omitted for clarity.

Fig. 25 is a sectional view substantially as taken on line 25-25 of Fig. 22 with portions omitted for clarity.

Fig. 26 is a side elevation view of the modular humeral prosthesis of Fig. 22 shown implanted in a shoulder joint.

Fig. 27 is an exploded side elevation view of a second preferred embodiment of certain modular instrumentation of the present invention for preparing a humerus to receive the modular humeral prosthesis of the present invention.

Fig. 28 is a sectional view substantially as taken on line 28-28 of Fig. 27.

Fig. 29 is a sectional view substantially as taken on line 29-29 of Fig. 27.

Fig. 30 is a plan view substantially as taken on line 30-30 of Fig. 27 with portions omitted for clarity.

Fig. 31 is a somewhat diagrammatic view showing the modular instrumentation of Fig. 28 being used to prepare a humerus to receive the modular humeral prosthesis of the present invention.

Fig. 32 is a sectional view substantially as taken on line 32-32 of Fig. 31.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Several embodiments of the invention are set forth, wherein parallel reference numbers relate to

corresponding elements in the various embodiments. For example, reference numerals 27, 2.27, 3.27, etc. all relate to a stem module. The description of each element for one embodiment holds true for corresponding elements of the further embodiments, unless indicated to the contrary.

A first preferred embodiment of the modular humeral prosthesis of the present invention is shown in Figs. 1-7 and identified by the numeral 11. The modular humeral prosthesis 11 is especially designed to replace at least a portion of the articulating surface 13 of a proximal humerus 15 of a shoulder joint 17 and for coacting with the articulating surface 19 of the scapular 21 of the shoulder joint 17. The shoulder joint 17 is shown somewhat diagrammatically in Fig. 9 before being prepared to receive the modular humeral prosthesis 11. As will be apparent to those skilled in the art, the articulating surface 13 of the proximal humerus 15 consists of a normally substantially hemispherical head while the articulating surface 19 of the scapular 21 is the glenoid cavity of the scapular 21 or a glenoid or scapular prosthesis (not shown) that replaces at least a portion of the natural articulating surface 19 of the scapular 21. To prepare the proximal humerus 15 to receive the humeral prosthesis 11, the head thereof is resected and a bore or medullary cavity 22 is prepared therein substantially along the proximal medullary canal thereof. The medullary cavity 22 includes an elongated distal portion 23 and a somewhat enlarged mouth portion 24.

The modular humeral prosthesis 11 includes a head module 25, a stem module 27, and an intermediate or neck module 29 for adjustably joining the head and stem modules 25, 27 relative to one another.

The stem module 27 includes an elongated body or shaft 30 having a proximal end 31 and a distal end 33 for

being implanted into the bore or medullary cavity 22 prepared in the proximal humerus 15. The distal end 33 may be rounded as shown in Fig. 1. A connecting means, such as a male taper 37, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the proximal end 31 of the shaft 30. The male taper 37 is preferably offset angularly from the shaft 30 of the stem module 27 as clearly shown in Figs. 1 and 2. Thus, the longitudinal axis 39 of the male taper 37 may be offset from the longitudinal axis 41 of the shaft 30 as shown in Fig. 1. The specific degree of the angle between the longitudinal axis 39 and the longitudinal axis 41 may vary as will now be apparent to those skilled in the art.

The stem module 27 preferably includes first indicia means 45 for allowing the version angle between the stem module 27 and the intermediate module 29 to be easily noted and accurately adjusted. The first indicia means 45 preferably includes a single indicia mark 47 on the proximal end 31 of the shaft 30. The single indicia mark 47 is preferably located just distally of the male taper 37. More specifically, the shaft 30 preferably includes a shoulder or flange 49 located at the proximal end 31 just distally of the male taper 37 and the indicia mark 47 preferably consists of a tic or groove in the shoulder 49 as clearly shown in Figs. 4-7.

The stem module 27 may be constructed out of various materials, in various sizes and shapes, and by various manners as will now be apparent to those skilled in the art. This also holds true for all stem, intermediate and head module embodiments disclosed herein. The cross sectional shape of at least the distal portion of the shaft 30 may be circular. Flutes or indentations 51 may optionally be provided in the distal portion of the shaft 30 as clearly shown in Figs. 1 and 2 for receiving bone cement or macro bone ingrowth when the stem module 27 is

implanted in the proximal humerus 15, as will now be apparent to those skilled in the art. An extraction groove 53 or the like may be provided on the male taper 37 as clearly shown in Fig. 1 to facilitate removal of the stem module 27 from the medullary cavity 22 of the proximal humerus 15 should it become necessary as will now be apparent to those skilled in the art. The stem modules, intermediate modules and head modules of all embodiments described herein may be constructed in the same manner and out of the same materials as the stem, trochanteral and head, respectively, disclosed in Paxson et al., U.S. Patent 5,002,581, issued March 26, 1991 and Paxson et al., U.S. Patent 5,135,529, issued August 4, 1992, the entire disclosures of both of which are expressly incorporated by reference herein and relied upon. This is also the case for the respective parts of the modular instrumentation.

The intermediate module 29 has a proximal end 55 for attachment to the head module 25 as shown in Fig. 2, and has a distal end 57 for attachment to the stem module 27 as shown in Figs. 2, 5, 6 and 7. More specifically, the intermediate module 29 preferably has a body 59 with one end of the body 59 defining the proximal end 55 and with the other end of the body 59 defining the distal end 57. A connecting means, such as a female taper 61, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the distal end 57 thereof for coacting with the connecting means of the stem module 27 (i.e., with the male taper 37) to allow the stem module 27 and the intermediate module 29 to be removably and adjustably secured to one another. The male and female tapers 37, 61 thus allow the stem module 27 and the intermediate module 29 to be removably attached to one another in a manner that allows the intermediate module 29 to be rotated relative to the stem module 27 as will now be apparent to those skilled in the art. A connecting means, such as a male taper 63, preferably of

the Morse taper type well known to those skilled in the art, is preferably provided at the proximal end 55 of the intermediate module 29. The male taper 63 may be offset angularly from the female taper 61. Thus, the longitudinal axis 65 of the female taper 61 may be at an angle relative to the longitudinal axis 67 of the male taper 63 as clearly shown in Fig. 1.

The intermediate module 29 preferably includes second indicia means 69 thereon for allowing the version angle between the stem module 27 and the intermediate module 29 to be noted and accurately adjusted. More specifically, when the distal end 57 of the intermediate module 29 is positioned adjacent the proximal end 31 of the stem module 27 with the male taper 37 of the connecting means of the stem module 27 positioned within the female taper 61 of the connecting means of the intermediate module 29, the first and second indicia means 45, 69 will align relative to one another to indicate the relative rotational alignment between the intermediate module 29 and the stem module 27. The second indicia means 69 preferably includes a series of spaced indicia marks 71 circumferentially oriented around the distal end 57 of the intermediate module 29. For this and all further embodiments described, the exact number and spacing of indicia marks 71 may vary. Thus, for example, the intermediate module 29 may include nine indicia marks 71 with each indicia mark spaced apart from one another approximately 11.5 degrees (note: only five indicia marks 71 are shown in the drawings for reasons of clarity). Each indicia mark 71 may consist of a tic or groove in the outer side of the body 59 adjacent the distal end 57 of the intermediate module 29.

The intermediate module 29, and further embodiments of the intermediate module, may be machined or otherwise constructed out of any surgical grade metal now apparent to those skilled in the art. A first indention 73 and a

second indention 75 are preferably provided in the proximal end of the body 59 on opposite sides of the male taper 63 for reasons which will hereinafter become apparent. The first indentation 73 may be round or hemispherical. The second indentation 75 may be elongated or slot-like. In addition, transverse apertures 77 are preferably provided through the body 59 as shown in Figs. 1 and 2 for reasons which will hereinafter become apparent.

For all embodiments of the intermediate module, the outer sides of the body 59 may be smooth or may be treated to stimulate or provide additional bone fixation. Thus, the outer sides of the body 59 may have a rough finish such as provided by sand blasting or the like, or may have a hydroxyapatite coating, etc., as will now be apparent to those skilled in the art.

The distal end 57 of the body 59 is preferably of circular cross-section so as to conform to the proximal end 31 and flange 49 of the stem 27 (see Fig. 4). The medial aspect or side 79 and the lateral aspect or side 81 of the body 59 preferably flare outwardly somewhat from the distal end 57 as clearly indicated in Fig. 3, thus providing a relatively oval cross-section through the body 59. The body may then narrow toward the proximal end 55 of the body. The shape of the body 59 is designed to substantially fit the mouth or proximal portion of the medullary cavity 22 prepared by a surgeon in the proximal humerus 15. The cross sectional shape of the body 59 of the intermediate module 29 is based on the typical somewhat oval cross sectional shape of the mouth and proximal portion of the properly prepared medullary cavity 22 in the proximal humerus 15 and may be shaped substantially as shown in Fig. 3.

The head module 25 of the modular humeral prosthesis 11 has a proximal end or side 83 for articulating with

the articulating surface 19 of the scapula 21, and has a distal end or side 85 for attachment to the proximal end 55 of the intermediate module 29. A connecting means, such as a female taper 87, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the distal end 85 for coacting with the connecting means of the proximal end 55 of the intermediate module 29 (i.e., with the male taper 63) to allow the intermediate module 29 and the head module 25 to be removably secured to one another. The male and female tapers 63, 87 thus allow the intermediate module 29 and the head module 25 to be removably attached to one another in a manner as will now be apparent to those skilled in the art. The proximal end or side 83 of the head module 25 may be hemispherical as shown in Figs. 1 and 2 for articulating with the articulating surface 19 of the scapular 21 or with a glenoid or scapular prosthesis (not shown).

A second preferred embodiment of the modular humeral prosthesis of the present invention is shown in Figs. 15-18 and identified by the numeral 2.11. The modular humeral prosthesis 2.11 is similar in basic function and construction to the modular humeral prosthesis 11, and reference should be made to the above description of the modular humeral prosthesis 11 for additional understanding.

The modular humeral prosthesis 2.11 includes a head module 2.25, a stem module 2.27, and an intermediate or neck module 2.29 for adjustably joining the head and stem modules 2.25, 2.27 relative to one another.

The stem module 2.27 includes an elongated body or shaft 2.30 having a proximal end 2.31 and a distal end 2.33 for being implanted into the bore or medullary cavity 22 prepared in the proximal humerus 15. The shaft 2.30 may be identical to the shaft 30. A connecting

means, such as a female taper 2.37, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the proximal end 2.31 of the shaft 2.30. The female taper 2.37 is preferably offset angularly from the shaft 2.30 of the stem module 2.27 as clearly shown in Fig. 15. Thus, the longitudinal axis 2.39 of the female taper 2.37 may be offset from the longitudinal axis 2.41 of the shaft 2.30 as shown in Fig. 15. The specific degree of the angle between the longitudinal axis 2.39 and the longitudinal axis 2.41 may vary as will now be apparent to those skilled in the art.

The stem module 2.27 preferably includes first indicia means 2.45 for allowing the version angle between the stem module 2.27 and the intermediate module 2.29 to be easily noted and accurately adjusted. The first indicia means 2.45 preferably includes a single indicia mark 2.47 on the proximal end of the stem module 2.27. More specifically, a shoulder or flange 2.49 may be provided on the proximal end of the stem module 2.27 adjacent the female taper 2.37 and the indicia mark 2.47 preferably consists of a tic or groove in the shoulder 2.49 as clearly shown in Fig. 17.

The intermediate module 2.29 has a proximal end 2.55 for attachment to the head module 2.25, and has a distal end 2.57 for attachment to the stem module 2.27. More specifically, the intermediate module 2.29 preferably has a body 2.59 with one end of the body 2.59 defining the proximal end 2.55 and with the other end of the body 2.59 defining the distal end 2.57. A connecting means, such as a male taper 2.61, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the distal end 2.57 of the body 2.59 for coacting with the connecting means of the stem module 2.27 (i.e., with the female taper 2.37) to allow the stem module 2.27 and the intermediate module 2.29 to be removably and adjustably secured to one another. The

female and male tapers 2.37, 2.61 thus allow the stem module 2.27 and the intermediate module 2.29 to be removably attached to one another in a manner that allows the intermediate module 2.29 to be rotated relative to the stem module 2.27 as will now be apparent to those skilled in the art. A connecting means, such as a female taper 2.63, preferably of the Morse taper type well known to those skilled in the art, is preferably provided in the proximal end 2.55 of the intermediate module 2.29. The female taper 2.63 may be offset angularly from the male taper 2.61. Thus, the longitudinal axis 2.65 of the male taper 2.61 may be at an angle relative to the longitudinal axis 2.67 of the female taper 2.63 as clearly shown in Fig. 15. A raised lip or edge 2.68 may be provided about the mouth of the female taper 2.63 as clearly shown in Fig. 15.

The intermediate module 2.29 preferably includes second indicia means 2.69 thereon for allowing the version angle between the stem module 2.27 and the intermediate module 2.29 to be noted and accurately adjusted. More specifically, when the distal end 2.57 of the intermediate module 2.29 is positioned adjacent the proximal end of the stem module 2.27 with the female taper 2.37 of the connecting means of the stem module 2.27 receiving the male taper 2.61 of the connecting means of the intermediate module 2.29, the first and second indicia means 2.45, 2.69 will align relative to one another to indicate the relative rotational alignment between the intermediate module 2.29 and the stem module 2.27 as will now be apparent to those skilled in the art. The second indicia means 2.69 preferably includes a series of spaced indicia marks 2.71 circumferentially oriented around the distal end 2.57 of the intermediate module 2.29. A concavity or indention 2.75 may be provided in the proximal end of the body 2.59 adjacent the female taper 2.63 for reasons which will hereinafter become apparent.

The shape of the body 2.59 of the intermediate module 2.29 is designed to substantially fit the mouth or proximal portion of the medullary cavity 22 prepared by a surgeon in the proximal humerus 15. The cross sectional shape of the body 2.59 of the intermediate module 2.29 is based on the typical somewhat oval cross sectional shape of the mouth and proximal portion of the properly prepared medullary cavity 22 in the proximal humerus 15 and may be shaped substantially as shown in Fig. 16.

The head module 2.25 of the modular humeral prosthesis 11 has a proximal end or side 2.83 for articulating with the articulating surface 19 of the scapula 21, and has a distal end or side 2.85 for attachment to the proximal end 2.55 of the intermediate module 2.29. A connecting means, such as a male taper 2.87, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the distal end 2.85 for coacting with the connecting means of the proximal end 2.55 of the intermediate module 2.29 (i.e., with the female taper 2.63) to allow the intermediate module 2.29 and the head module 2.25 to be removably secured to one another. The female and male tapers 2.63, 2.87 thus allow the intermediate module 2.29 and the head module 2.25 to be removably attached to one another in a manner as will now be apparent to those skilled in the art. The proximal end or side 2.83 of the head module 2.25 may be substantially hemispherical (or shaped as a section of a hemisphere) as shown in Fig. 15 for articulating with the articulating surface 19 of the scapular 21 or with a glenoid or scapular prosthesis (not shown). An annular concavity 2.89 may be provided in the distal side 2.85 of the head module 2.25 about the base of the male taper 2.87 as shown in Figs. 15 and 18 for receiving the raised lip 2.68 of the intermediate module 2.29. The concavity 2.89 and raised lip 2.68, along with the generally flat distal end 2.85 of the hemispherical head module 2.25, act together to provide a

more compact prosthesis which can be more easily assembled during surgery within the small confines of the humerus region. In particular, the conforming concavity/lip provides a more secure connection which allows for a reduced exposed length of the male taper 2.87.

A third preferred embodiment of the modular humeral prosthesis of the present invention is shown in Figs. 19-21 and identified by the numeral 3.11. The modular humeral prosthesis 3.11 is similar in basic function and construction to the modular humeral prostheses 11, 2.11 and reference should be made to the above description of the modular humeral prostheses 11, 2.11 for additional understanding.

The modular humeral prosthesis 3.11 includes a head module 3.25, a stem module 3.27, and an intermediate or neck module 3.29 for adjustably joining the head and stem modules 3.25, 3.27 relative to one another.

The stem module 3.27 is preferably identical to the stem module 2.27 hereinabove described relative to the modular humeral prosthesis 2.11 and reference should be made to the above description of the stem module 2.27 for a complete disclosure thereof. Thus, for example, the stem module 3.27 preferably includes a female taper 3.37 identical to the female taper 2.37 of the stem module 2.27, and first indicia means 3.45 identical to the first indicia means 2.45 of the stem module 2.27.

The intermediate module 3.29 has a proximal end 3.55 for attachment to the head module 3.25, and has a distal end 3.57 for attachment to the stem module 3.27. More specifically, the intermediate module 3.29 preferably has a body 3.59 with one end of the body 3.59 defining the proximal end 3.55 and with the other end of the body 3.59 defining the distal end 3.57. A connecting means, such as

a male taper 3.61, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the distal end 3.57 of the body 3.59 for coacting with the connecting means of the stem module 3.27 (i.e., with the female taper 3.37) to allow the stem module 3.27 and the intermediate module 3.29 to be removably and adjustably secured to one another. The female and male tapers 3.37, 3.61 thus allow the stem module 3.27 and the intermediate module 3.29 to be removably attached to one another in a manner that allows the intermediate module 3.29 to be rotated relative to the stem module 3.27 as will now be apparent to those skilled in the art. A connecting means, such as a male taper 3.63, preferably of the Morse taper type well known to those skilled in the art, is preferably provided in the proximal end 3.55 of the intermediate module 3.29. The male taper 3.63 may be offset angularly from the male taper 3.61. Thus, the longitudinal axis 3.65 of the male taper 3.61 may be at an angle relative to the longitudinal axis 3.67 of the male taper 3.63 as clearly shown in Fig. 19.

The intermediate module 3.29 preferably includes second indicia means 3.69 thereon for allowing the version angle between the stem module 3.27 and the intermediate module 3.29 to be noted and accurately adjusted. More specifically, when the distal end 3.57 of the intermediate module 3.29 is positioned adjacent the proximal end of the stem module 3.27 with the female taper 3.37 of the connecting means of the stem module 3.27 receiving the male taper 3.61 of the connecting means of the intermediate module 3.29, the first and second indicia means 3.45, 3.69 will align relative to one another to indicate the relative rotational alignment between the intermediate module 3.29 and the stem module 3.27 as will now be apparent to those skilled in the art. The second indicia means 3.69 preferably includes a series of spaced indicia marks 3.71 circumferentially

oriented around the distal end 3.57 of the intermediate module 3.29.

The shape of the body 3.59 is designed to substantially fit the mouth or proximal portion of the medullary cavity 22 prepared by a surgeon in the proximal humerus 15. The cross sectional shape of the body 3.59 of the intermediate module 3.29 is based on the typical somewhat oval cross sectional shape of the mouth and proximal portion of the properly prepared medullary cavity 22 in the proximal humerus 15 and may be shaped substantially as shown in Fig. 20.

The head module 3.25 is preferably identical to the head module 25 hereinabove described relative to the modular humeral prosthesis 11 and reference should be made to the above description of the head module 25 for a complete disclosure thereof. Thus, for example, the head module 3.25 preferably includes a female taper 3.87 identical to the female taper 87 of the head module 25 for coacting with the connecting means of the proximal end 3.55 of the intermediate module 3.29 (i.e., with the male taper 3.63) to allow the intermediate module 3.29 and the head module 3.25 to be removably secured to one another.

A fourth preferred embodiment of the modular humeral prosthesis of the present invention is shown in Figs. 22-26 and identified by the numeral 4.11. The modular humeral prosthesis 4.11 is similar in basic function and construction to the modular humeral prostheses 11, 2.11, 3.11 and reference should be made to the above description of the modular humeral prostheses 11, 2.11, 3.11 for additional understanding.

The modular humeral prosthesis 4.11 includes a head module 4.25, a stem module 4.27, and an intermediate or neck module 4.29 for adjustably joining the head and stem

modules 4.25, 4.27 relative to one another.

The stem module 4.27 is preferably identical to the stem module 27 hereinabove described relative to the modular humeral prosthesis 11 and reference should be made to the above description of the stem module 27 for a complete disclosure thereof. Thus, for example, the stem module 4.27 preferably includes a male taper 4.37 identical to the male taper 37 of the stem module 27, and first indicia means 4.45 identical to the first indicia means 45 of the stem module 27.

The intermediate module 4.29 has a proximal end 4.55 for attachment to the head module 4.25, and has a distal end 4.57 for attachment to the stem module 4.27. More specifically, the intermediate module 4.29 preferably has a body 4.59 with one end of the body 4.59 defining the proximal end 4.55 and with the other end of the body 4.59 defining the distal end 4.57. A connecting means, such as a female taper 4.61, preferably of the Morse taper type well known to those skilled in the art, is preferably provided at the distal end 4.57 of the body 4.59 for coacting with the connecting means of the stem module 4.27 (i.e., with the male taper 4.37) to allow the stem module 4.27 and the intermediate module 4.29 to be removably and adjustably secured to one another. The male and female tapers 4.37, 4.61 thus allow the stem module 4.27 and the intermediate module 4.29 to be removably attached to one another in a manner that allows the intermediate module 4.29 to be rotated relative to the stem module 4.27 as will now be apparent to those skilled in the art. A connecting means, such as a female taper 4.63, preferably of the Morse taper type well known to those skilled in the art, is preferably provided in the proximal end 4.55 of the intermediate module 4.29. The female taper 4.63 may be offset angularly from the female taper 4.61. Thus, the longitudinal axis 4.65 of the female taper 4.61 may be at an angle relative to the

longitudinal axis 4.67 of the female taper 4.63 as clearly shown in Fig. 22. A raised lip or edge 4.68 may be provided about the mouth of the female taper 2.63 as clearly shown in Fig. 22.

The intermediate module 4.29 preferably includes second indicia means 4.69 thereon for allowing the version angle between the stem module 4.27 and the intermediate module 4.29 to be noted and accurately adjusted. More specifically, when the distal end 4.57 of the intermediate module 4.29 is positioned adjacent the proximal end of the stem module 4.27 with the male taper 4.37 of the connecting means of the stem module 4.27 extending into the female taper 4.61 of the connecting means of the intermediate module 4.29, the first and second indicia means 4.45, 4.69 will align relative to one another to indicate the relative rotational alignment between the intermediate module 4.29 and the stem module 4.27 as will now be apparent to those skilled in the art. The second indicia means 4.69 preferably includes a series of spaced indicia marks 4.71 circumferentially oriented around the distal end 4.57 of the intermediate module 4.29. A concavity or indention 4.75 may be provided in the proximal end of the body 4.59 adjacent the female taper 4.63 for reasons which will hereinafter become apparent.

The shape of the body 4.59 is designed to substantially fit the mouth or proximal portion of the medullary cavity 22 prepared by a surgeon in the proximal humerus 15. The cross sectional shape of the body 4.59 of the intermediate module 4.29 is based on the typical somewhat oval cross sectional shape of the mouth and proximal portion of the properly prepared medullary cavity 22 in the proximal humerus 15 and may be shaped substantially as shown in Fig. 23.

The head module 4.25 is preferably identical to the head module 2.25 hereinabove described relative to the modular humeral prosthesis 2.11 and reference should be made to the above description of the head module 2.25 for a complete disclosure thereof. Thus, for example, the head module 4.25 preferably includes a male taper 4.87 identical to the male taper 2.87 of the head module 2.25 for coacting with the connecting means of the proximal end 4.55 of the intermediate module 4.29 (i.e., with the female taper 4.63) to allow the intermediate module 4.29 and the head module 4.25 to be removably secured to one another. An annular concavity 4.89 may be provided in the distal side of the head module 4.25 about the base of the male taper 4.87 as shown in Figs. 22 and 26 for receiving the raised lip 4.68 of the intermediate module 4.29 as shown in Fig. 26.

A first preferred embodiment of the modular instrumentation of the present invention for preparing the proximal humerus 15 to receive the modular humeral prosthesis 11 is shown in Figs. 8 and 10-14, and identified by the numeral 111.

The modular instrumentation 111 includes a stem module 113, one or more rasp modules 115, and a handle or head module 117.

The stem module 113 includes a shaft 119 for being inserted into the distal portion 23 of the medullary cavity 22 in the proximal humerus 15. The shaft 119 has a proximal end 123 and a distal end 125. The distal end 125 is preferably rounded as shown in Fig. 8. The stem module 113 includes an attachment means or stud 127 attached to the proximal end 123 of the shaft 119 for attaching the rasp module 115 and the handle module 117 to the shaft 119. The attachment means 127 preferably includes an elongated arm 129 having a proximal end 131 and a distal end 133 attached to the proximal end 123 of the shaft

119. The arm 129 is preferably offset angularly from the shaft 119 as clearly shown in Fig 8. Thus, the longitudinal axis 135 of the arm 129 may be offset angularly from the longitudinal axis 137 of the shaft 119 by an angle substantially the same as the angle between the longitudinal axis 39 of the male taper 37 and the longitudinal axis 41 of the shaft 30 of the stem module 27. The stem module 113 preferably has first indicia means 139 thereon. The first indicia means 139 preferably includes a single indicia mark 141 on the arm 129 adjacent the proximal end 131 thereof. The indicia mark 141 preferably consists of a tic or groove in the arm 129 as shown in Figs. 8 and 11-14.

The stem module 113 (as well as the rasp module and handle module, for all further embodiments) may be constructed out of various materials, in various sizes and shapes, and by various manners as will now be apparent to those skilled in the art. The cross sectional shape of at least the distal portion of the shaft 119 may be circular and sized so as to fit within the distal portion 23 of the medullary cavity 22 prepared in the proximal humerus 15. A transverse groove 143 is preferably provided about the arm 129 adjacent the proximal end 131 thereof.

Each rasp module 115 has a proximal end 145 for engaging the handle module 117, and has a distal end 147 for engaging the proximal end 123 of the shaft 119 of the stem module 113. More specifically, each rasp module 115 preferably has a body 149 with one end of the body 149 defining the proximal end 145 and with the other end of the body 149 defining the distal end 147. In order to properly prepare the humerus to receive the prosthesis, the distal end 147 should preferably be of generally circular cross-section, while the region proximal of the distal end should open out from the distal end to have a generally oval cross-section. An aperture 151

preferably extends completely through the body 149 between the proximal and distal ends 145, 147 thereof to allow the arm 129 of the stem module 113 to extend therethrough. The coaction between the arm 129 and aperture 151 allows the stem module 113 and the rasp module 115 to be removably attached to one another in a manner that allows the rasp module 115 to be rotated relative to the shaft 119 of the stem module 113 as will now be apparent to those skilled in the art. Each rasp module 115 preferably has second indicia 153 thereon so that when the stem module 113 and one of the rasp modules 115 are attached to one another, the first and second indicia 139, 153 align relative to one another to indicate the relative rotational alignment between the stem module 113 and the rasp module 115. The second indicia 153 preferably includes a series of spaced indicia marks 155 circumferentially oriented around the proximal end 145 of the rasp module 115. The exact number and spacing of indicia marks 155 may vary. Thus, for example, each rasp module 115 may include nine indicia marks 155 with each indicia mark 155 spaced apart from one another approximately 11.5 degrees (note: only five indicia marks 155 are shown in the drawings for reasons of clarity). Each indicia mark 155 may consist of a tic or groove in the outer side of the body 149 adjacent the proximal end 145 of each rasp module 115.

The handle or head module 117 is provided for attachment to the attachment means 127 of the stem module 113 to allow a surgeon to drive the stem module 113 and rasp module 115 into the proximal humerus 15 to rasp or otherwise form the mouth portion 24 in the medullary cavity 22 in the proximal humerus 15. The handle module 117 preferably includes a flattened upper surface 159 against which a hammer 161 may be struck to drive the assembled unit into the proximal humerus 15 and cause the rasp module 115 to form or create the shaped mouth portion 24 in the medullary cavity 22 in the proximal

humerus 15 as diagrammatically indicated in Fig. 10. The handle module 117 preferably includes an interlock mechanism 163 for releasably attachment to the arm 129 of the stem module 113. The interlock mechanism 163 may include means for coacting with the groove 143 about the arm 129 of the stem module 113 to releasably secure the stem module 113 to the handle module 117 with a rasp module 115 trapped therebetween as clearly shown in Fig. 10.

A second preferred embodiment of the modular instrumentation of the present invention for preparing the proximal humerus 15 to receive the modular humeral prosthesis of the present invention is shown in Figs. 27-32, and identified by the numeral 2.111.

The modular instrumentation 2.111 includes a stem module 2.113, one or more rasp modules 2.115, and a handle or head module 2.117.

The stem module 2.113 includes a shaft 2.119 for being inserted into the distal portion 23 of the medullary cavity 22 in the proximal humerus 15. The shaft 2.119 has a proximal end 2.123 and a distal end 2.125. The distal end 2.125 is preferably rounded as shown in Fig. 27. The stem module 2.113 includes an attachment means or stud 2.127 attached to the proximal end 2.123 of the shaft 2.119 for attaching the rasp module 2.115 to the shaft 2.119. The attachment means 2.127 preferably includes an elongated arm 2.129 having a proximal end 2.131 and a distal end 2.133 attached to the proximal end 2.123 of the shaft 2.119. A boss or key 2.134 preferably projects outwardly from the proximal end 2.131 of the elongated arm 2.129 as clearly shown in Figs. 27, 30 and 31 for use in securely but adjustably attaching the rasp module 2.115 to the shaft 2.119 in a manner which will hereinafter become apparent. The arm 2.129 is preferably offset angularly from the shaft 2.119 as clearly shown in

Fig 27. Thus, the longitudinal axis 2.135 of the arm 2.129 may be offset angularly from the longitudinal axis 2.137 of the shaft 2.119 by an angle substantially the same as the angle between the longitudinal axis 39 of the male taper 37 and the longitudinal axis 41 of the shaft 30 of the stem module 27 of the modular humeral prosthesis 11 and the longitudinal axis 2.39 of the female taper 2.37 and the longitudinal axis 2.41 of the shaft 30 of the stem module 2.27 of the modular humeral prosthesis 2.11, etc. The stem module 2.113 preferably has first indicia means 2.139 thereon. The first indicia means 2.139 preferably includes a single indicia mark 2.141 on the face surface of the proximal end 2.131 of the arm 2.129 thereof as shown in Figs. 30 and 32. The indicia mark 2.141 preferably consists of a tic or groove in the face surface of the proximal end 2.131 of the arm 2.129.

The cross sectional shape of at least the distal portion of the shaft 2.119 may be circular and sized so as to fit within the distal portion 23 of the medullary cavity 22 prepared in the proximal humerus 15. The stem module 2.113 may be constructed in the same basic manner and out of the same materials as hereinabove disclosed relative to the stem module 113.

Each rasp module 2.115 has a proximal end 2.145 for engaging the handle module 2.117, and has a distal end 2.147 for engaging the proximal end 2.123 of the shaft 2.119 of the stem module 2.113. More specifically, each rasp module 2.115 preferably has a body 2.149 with one end of the body 2.149 defining the proximal end 2.145 and with the other end of the body 2.149 defining the distal end 2.147. A keyway 2.150 and a mating aperture 2.151 preferably extend from the distal end 2.147 of the body 2.149 to receive the arm 2.129 of the stem module 2.113 as shown in Fig. 31. An annular groove or raceway 2.152 extends around the aperture 2.151 at the upper end of the

keyway 2.150 with the keyway 2.150 opening into raceway 2.152. The aperture 2.151 preferably extends completely through the body 2.149 as clearly shown in Figs. 27 and 31. The coaction between the arm 2.129 key 2.134, keyway 2.150, aperture 2.151 and raceway 2.152 allows the stem module 2.113 and the rasp module 2.115 to be removably attached to one another in a manner that allows the rasp module 2.115 to be rotated about the arm 2.129 of the stem module 2.113 and relative to the shaft 2.119 of the stem module 2.113.

Each rasp module 2.115 preferably has second indicia 2.153 thereon so that when the stem module 2.113 and one of the rasp modules 2.115 are attached to one another, the first and second indicia 2.139, 2.153 align relative to one another to indicate the relative rotational alignment between the stem module 2.113 and the rasp module 2.115. The second indicia 2.153 preferably includes a series of spaced indicia marks 2.155 circumferentially oriented around a portion of the side of the aperture 2.151 in a position so that the indicia marks 2.155 can be observed when looking into the aperture 2.151 from the proximal end 2.145 of the body 2.149 with the handle module 2.117 separated from the stem and rasp modules 2.113, 2.115 as clearly shown in Fig. 32. The exact number and spacing of indicia marks 2.155 may vary. Thus, for example, each rasp module 2.115 may include nine indicia marks 2.155 with each indicia mark 2.155 spaced apart from one another approximately 11.5 degrees (note: only five indicia marks 2.155 are shown in the drawings for reasons of clarity). Each indicia mark 2.155 may consist of a tic or groove in the side of the aperture 2.151 as will now be apparent to those skilled in the art.

The handle or head module 2.117 is provided for attachment to a rasp module 2.115 to allow a surgeon to drive the stem module 2.113 and rasp module 2.115 into

the proximal humerus 15 to rasp or otherwise form the mouth portion 24 in the medullary cavity 22 in the proximal humerus 15. The handle module 2.117 may include a flattened upper surface 2.157 against which a hammer (not shown) may be struck to drive the assembled unit into the proximal humerus 15 and cause the rasp module 2.115 to form or create the shaped mouth portion 24 in the medullary cavity 22 in the proximal humerus 15 as diagrammatically indicated in Fig. 31. The handle module 2.117 preferably includes an interlock mechanism 2.163 for releasably attachment to the rasp module 2.115. The interlock mechanism 163 preferably includes a first pin 2.167 for extending into the proximal end of the aperture 2.151 and a second pin 2.169 for extending into a concavity 2.171 formed in the proximal end 2.145 of the body 2.149 a spaced distance from the proximal end of the aperture 2.151 as diagrammatically illustrated in Fig. 31 to releasably secure the rasp module 2.115 to the handle module 2.117. One or both pins 2.167, 2.169 may be retractable by mechanical means or the like to allow easy attachment and removal of the handle module 2.117 from the rasp module 2.115 as will now be apparent to those skilled in the art. Additionally, it should be noted that the handle module 2.117 as thus constructed can be releasably attached to the intermediate module 2.29 of the modular humeral prosthesis 2.11 or the intermediate module 4.29 of the modular humeral prosthesis 4.11 in substantially the same manner to aid in implanting or removing the intermediate modules 2.29, 4.29 of the modular humeral prostheses 2.11, 4.11 respectively. That is, the first pin 2.167 of the interlock mechanism 2.163 may extend into the proximal end of the female taper 2.63 of the intermediate module 2.29 or the female taper 4.63 of the intermediate module 4.29 and the second pin 2.169 of the interlock mechanism 2.163 may extend into concavity 2.75 of the intermediate module 2.29 or the concavity 4.75 of the intermediate module 4.29 to thereby lock either the intermediate module 2.29 or the

intermediate module 4.29 to the handle module 2.117 as will now be apparent to those skilled in the art.

The preferred embodiment of the method of the present invention for preparing the proximal humerus 15 to receive the modular humeral prosthesis of the present invention and for implanting the module humeral prosthesis of the present invention can be explained as follows in conjunction with the first embodiment of the modular humeral prosthesis 11 of the present invention and the first embodiment of the modular instrumentation 111 of the present invention. It will be understood by those skilled in the art that the same method or substantially the same method can be also used in conjunction with the second, third or forth embodiments of the modular humeral prosthesis of the present invention and the second embodiment of the modular instrumentation of the present invention. The surgeon begins by removing the head of the proximal humerus 15 by a rough resection substantially along the plane 165 as shown in Fig. 9 in any manner now apparent to those skilled in the art. The surgeon then reams or otherwise forms the distal portion 23 of the bore or medullary cavity 22 substantially along the long axis or proximal medullary canal of the proximal humerus 15, typically sequentially using reamers of progressively increasing diameters until satisfied with the distal portion 23 of the medullary cavity 22 thus formed (normally until the reamer contacts compact or cortical bone). The reamers employed are normally cylindrical in shape with helical or longitudinal flutes which cut the bone. Once the appropriate or optimum size and shaped distal portion 23 is thus determined and formed, the surgeon then selects a stem module 113 having a shaft 119 with substantially the same diameter and length as the distal portion 23 of the medullary cavity 22 thus formed, selects a rasp module 115 of an appropriate shape and size depending on the structure and condition of the proximal humerus 15, and

assembles the unit by inserting arm 129 through the aperture 151 of the selected rasp module 115 and then securing the handle module 117 to the stem module 113 by the interlock mechanism 163 as will now be apparent to those skilled in the art to trap the rasp module 115 therebetween. The rasp module 115 can freely rotate on the arm 129 to vary the degree of version between the shaft 119 and the rasp module 115. The surgeon then drives the assembled modular instrumentation 111 into the proximal humerus 15 by, for example, striking the upper surface 159 of the handle portion 117 with the hammer 161. The surgeon may then sequentially replace the rasp module 115 with progressively larger rasp modules until satisfied with the mouth portion 24 of the medullary cavity 22 thus formed in the proximal humerus 15. During the rasping process, the surgeon is free to rotate the rasp module 115 relative to the stem module 113 to determine the optimum orientation or version of the rasp module 115 by visualizing the best position for the rasp module 115 each time the rasp module 115 is driven into the proximal humerus 15. When the surgeon is satisfied with the mouth portion 24 of the medullary cavity 22 thus formed in the proximal humerus 15, the precise angle of version between the rasp module 115 and stem module 113 is noted by simply noting which spaced indicia mark 155 on the rasp module 115 is aligned with the single indicia mark 141 on the stem module 113. The surgeon may easily do this by leaving the stem module 113 and rasp module 115 in the proximal humerus 15 after the mouth portion 24 of the medullary cavity 22 has been fully formed, removing the handle module 117 from the stem module 113, and merely looking at the indicia 139, 153. The surgeon then selects a stem module 27 that corresponds to the size of the stem module 113 used in final preparation of the mouth portion 24 of the medullary cavity 22, selecting an intermediate module 29 that corresponds in size and shape to the final rasp module 115 used in preparing the mouth portion 24 of the medullary cavity

22, and assembles the selected modules 27, 29 with the single indicia mark 47 of the selected stem module 27 aligned with one of the spaced indicia marks 71 of the intermediate module 29 in exactly the same relationship as noted between the specific indicia mark 155 on the rasp module 115 and the single indicia mark 141 on the stem module 113. While the selected modules 27, 29 can be assembled in various manners now apparent to those skilled in the art, it is preferred that the selected stem module 27 be held securely in a jig or the like and the selected intermediate module 29 be forced onto the selected stem module 27 by engaging the indentation 73 on the proximal end 55 of the selected intermediate module 29 with a punch or the like (not shown) to forcibly urge the male and female tapers 37, 61 together. The head module 25 can be secured to the male taper 63 of the selected intermediate module 29 by forcibly urging the male and female tapers 63, 87 together. Next, the assembled prosthesis 11 can be implanted into the proximal humerus 15 by merely inserting the distal end 33 of the shaft 30 into the distal portion 23 of the medullary cavity 22 in the proximal humerus 15. The indentation 75 on the proximal end 55 of the selected intermediate module 29 can be engaged with a punch or the like (not shown) to allow the surgeon to force the assembled modules 27, 29 into the medullary cavity 22. In the event the proximal humerus 15 is fractured, etc., the surgeon can suture the intermediate module 29 to the proximal humerus 15 using the apertures 77 as will now be apparent to those skilled in the art.

Although the present invention has been described and illustrated with respect to preferred embodiments thereof and a preferred use therefor, it is not to be so limited since modifications and changes can be made therein which are within the full intended scope of the invention.

Claims

1. A modular humeral prosthesis for replacing at least a portion of the articulating surface of a proximal humerus of a shoulder joint and for coacting with the articulating surface of the scapular of the shoulder joint, the modular humeral prosthesis comprising:

(a) a stem module having a proximal end for mating connection with an intermediate module and having a distal end for insertion into the proximal humerus;

(b) a head module having a proximal end for articulating with the articulating surface of the scapular and having a distal end for mating connection with the intermediate module; and

(c) the intermediate module having a proximal end for mating connection to said distal end of said head module and having a distal end for adjustable mating connection to said proximal end of said stem module, the distal end of the intermediate module having a generally circular cross-section

2. The prosthesis of claim 1, wherein the intermediate module has lateral sides, and said lateral sides flare outwardly from the distal end of the intermediate module toward the proximal end thereof to provide the intermediate module with a generally oval cross-section in the region proximal of the distal end.

3. The modular humeral prosthesis of claim 1 in which said intermediate module and said stem module can be rotated relative to one another.

4. The modular humeral prosthesis of claim 3 in which said stem module has first indicia means thereon; and in which said intermediate module has second indicia means thereon so that when said distal end of said intermediate module is attached to said proximal end of said stem module, said first and second indicia means

align relative to one another to indicate the relative rotational alignment between said intermediate module and said shaft module.

5. The modular humeral prosthesis of claim 4 in which said first indicia means includes a single indicia mark on said proximal end of said shaft module; and in which said second indicia means includes a series of spaced indicia marks circumferentially oriented around said distal end of said intermediate module.

6. The prosthesis of claim 1, wherein the proximal end of the intermediate module has a female connection means for receiving a male connection means of the distal end of the head module.

7. The prosthesis of claim 1, wherein a male connection means is provided on one of the proximal end of the intermediate module and the distal end of the head module, and a female connection means is provided on the other, wherein said one end bearing the male connection means has a concavity extending inwardly from said end and generally surrounding a base of the male connection means, and wherein said other end has a raised lip extending outwardly from said other end, said raised lip generally surrounding the female connection means and matingly conforming to said concavity.

8. The prosthesis of claim 7, wherein the proximal end of the intermediate module has a female connection means for receiving a male connection means of the distal end of the head module.

9. The prosthesis of claim 1, wherein the head module is shaped as a section of a hemisphere.

10. The prosthesis of claim 1, wherein the intermediate module has a connection means on the

proximal end thereof defined along a first longitudinal axis for mating connection with a connection means of the distal end of the head module, and wherein the intermediate module has a concavity on the proximal end thereof defined along a second longitudinal axis not parallel to the first longitudinal axis for receiving a conforming pin of a handle module.

11. Modular instrumentation for preparing the proximal humerus of a shoulder joint to receive a modular humeral prosthesis, said modular instrumentation comprising:

(a) a stem module for inserting into a medullary cavity prepared in the proximal humerus, said stem having a proximal end and a distal end; and

(b) a rasp module for adjustable attachment to said proximal end of said stem module and for forming a mouth portion in the medullary cavity as said stem module is inserted into the medullary cavity, said rasp module and said stem module being rotatable relative to one another, the distal end of the rasp module having a generally circular cross-section, and the rasp module having a generally oval cross-section in the region proximal the distal end.

12. The modular instrumentation of claim 11, wherein said stem module includes an elongated arm and includes a key projecting from said elongated arm; and in which said rasp module has an aperture therein for receiving said elongated arm of said stem module and has a keyway mating with said aperture for receiving said key of said stem module for allowing said arm of said stem module to extend into said aperture of said rasp module.

13. The modular instrumentation of claim 11 in which said stem module has first indicia means thereon; and in which said rasp module has second indicia means thereon so that when said rasp module is attached to said

proximal end of said stem module, said first and second indicia means align relative to one another to indicate the relative rotational alignment between said rasp module and said shaft module.

14. The instrumentation of claim 13 in which said first indicia means includes a single indicia mark on said proximal end of said stem module; and in which said second indicia means includes a series of spaced indicia marks circumferentially oriented around said distal end of said intermediate module.

15. The modular instrumentation of claim 12 in which said rasp module has an annular raceway mating with said keyway for receiving said key of said stem module for allowing said stem module to rotate about said elongated arm of said stem module and for securing said stem module and said rasp module to one another.

16. The modular instrumentation of claim 15 in which is included a handle module for attachment relative to said proximal end of said stem module with said rasp module positioned therebetween

17. The modular instrumentation of claim 16, wherein the rasp module has a concavity in the proximal end thereof and wherein a proximal end of the aperture in the rasp module opens out through the proximal end of the rasp module, and the handle module comprises a first pin extending along a first longitudinal axis from a distal end of the handle module for insertion into the proximal end of the aperture, and the handle module comprises a second pin extending along a second longitudinal axis not parallel to the first longitudinal axis for insertion into the concavity in the rasp module, one of said first and second pins being retractable along its longitudinal axis.

18. A method for implanting a modular humeral prosthesis to replace at least a portion of the articulating surface of a proximal humerus of a shoulder joint; said method comprising the steps of:

(a) preparing a medullary cavity in the proximal humerus;

(b) forcing modular instrumentation into said medullary cavity to prepare an enlarged mouth portion in said medullary cavity, said modular instrumentation including a stem module for inserting into the medullary cavity prepared in the proximal humerus and a rasp module adjustably attached to said stem module, said rasp module being rotatable relative to said stem module; said stem module having first indicia means thereon; said rasp module has second indicia means thereon for coacting with said first indicia to indicate the relative rotational alignment between said rasp module and said shaft module;

(c) inserting a modular humeral prosthesis into said medullary cavity after said modular instrumentation has prepared said enlarged mouth portion therein; said modular humeral prosthesis including a stem module for insertion into medullary cavity, a head module, and an intermediate module for insertion into said enlarged mouth portion of said medullary cavity and adjustably joining said stem module and said head module to one another; said stem module having first indicia means thereon; said intermediate module having second indicia means for coacting with said first indicia means to indicate the relative rotational alignment between said intermediate module and said shaft module and to allow said intermediate module to be rotated relative to said stem module an amount corresponding to the relative rotational alignment between said rasp module and said shaft module of said modular instrumentation as indicated by said first and second indicia means of said modular instrumentation.

FIG. 1

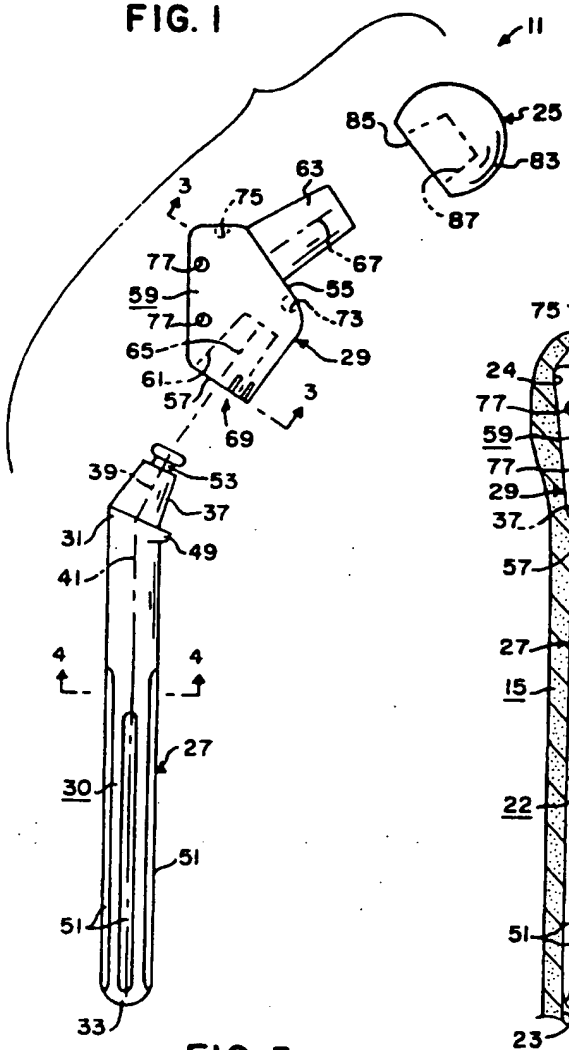


FIG. 2

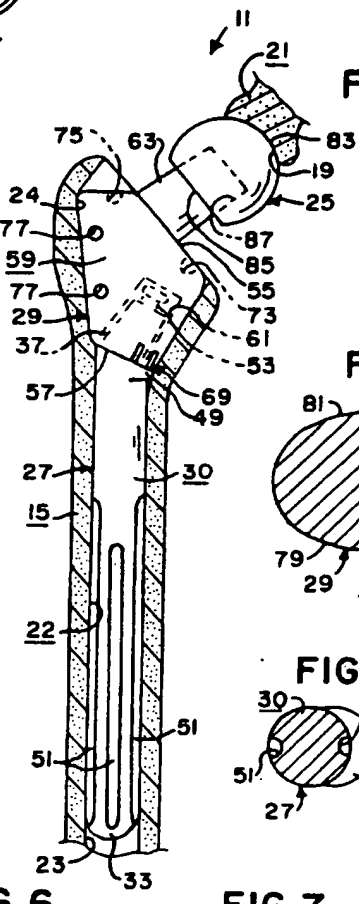


FIG. 3

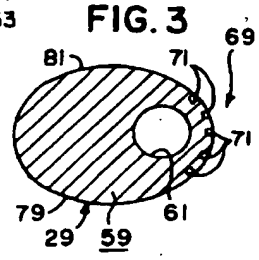


FIG. 4

FIG. 5

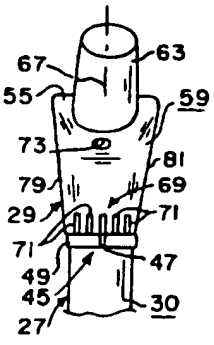


FIG. 6

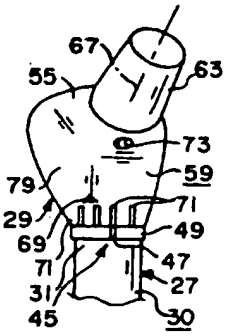


FIG. 7

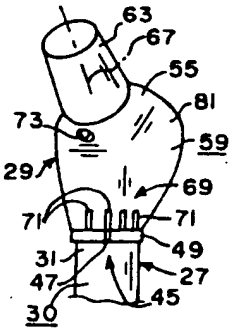


FIG. 8

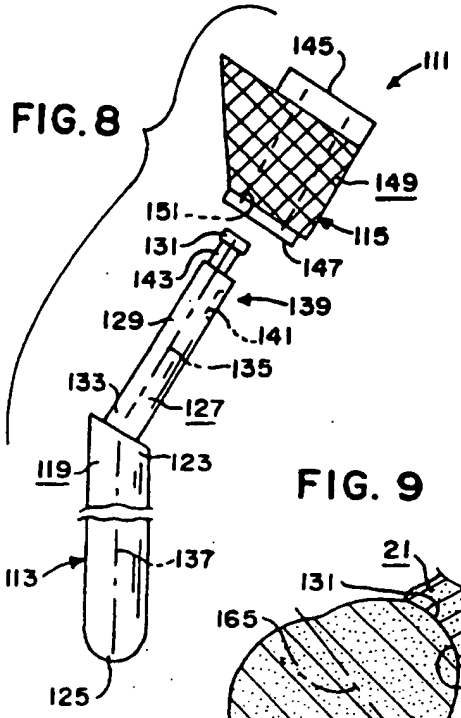


FIG. 9

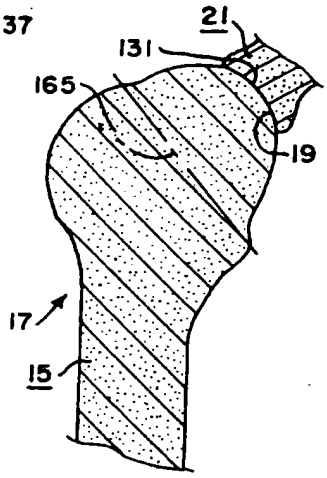


FIG. 10

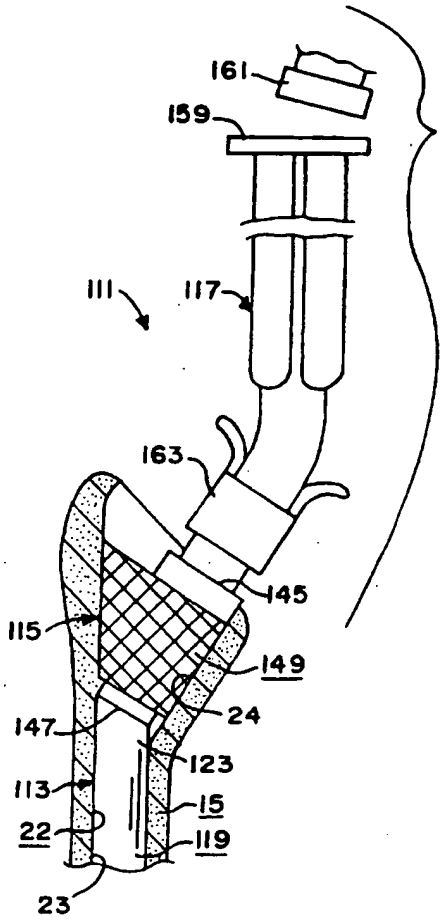


FIG. 11

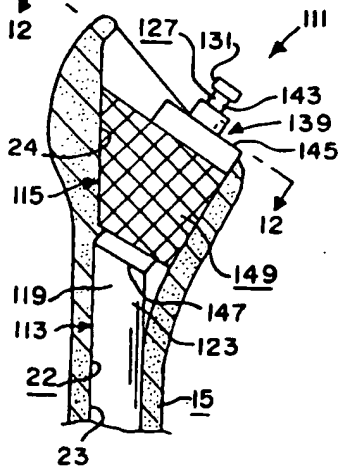


FIG. 12

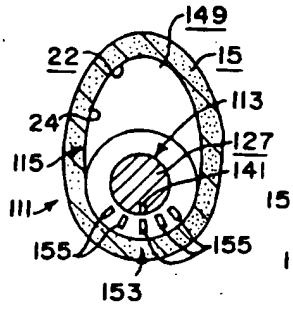


FIG. 13

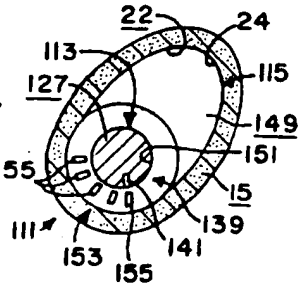


FIG. 14

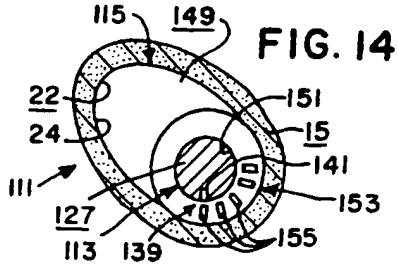


FIG. 15

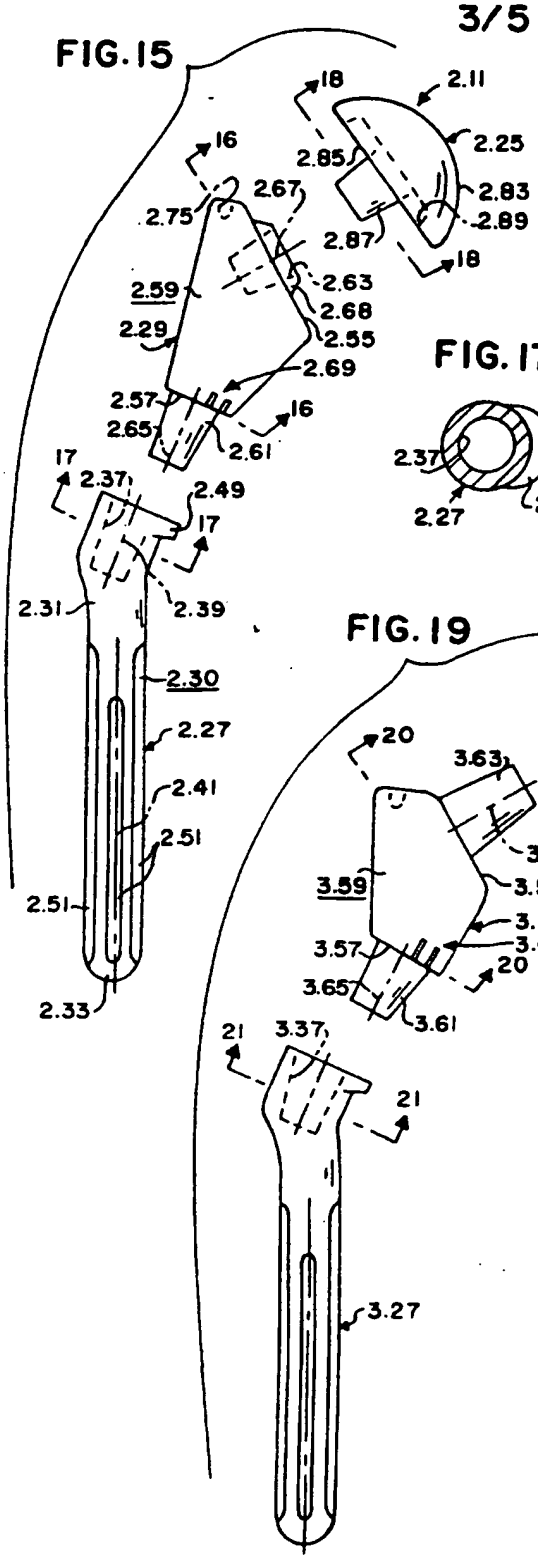


FIG. 16

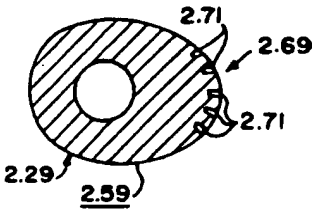


FIG. 17

FIG. 18

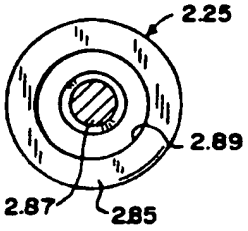


FIG. 19

FIG. 20

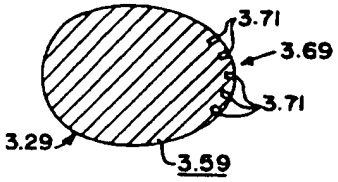


FIG. 21

FIG. 22

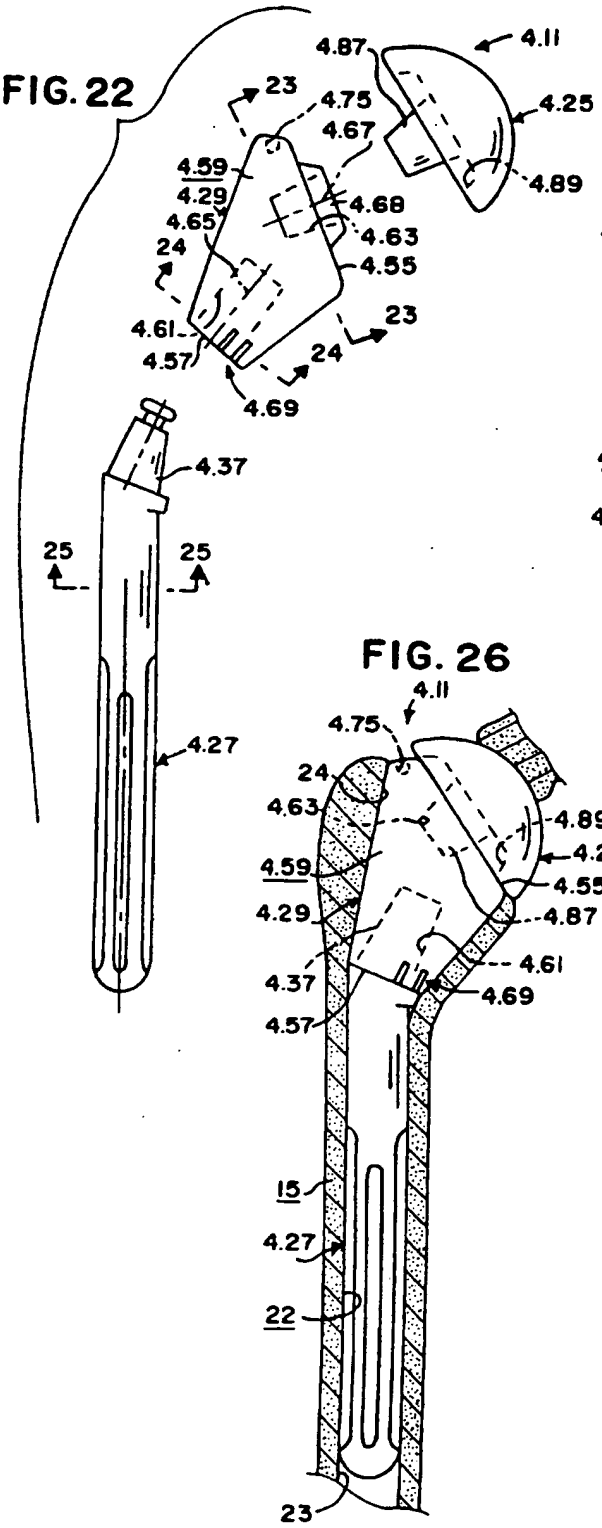


FIG. 23

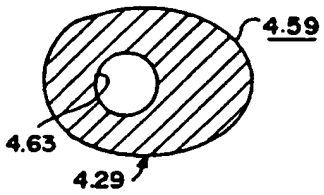


FIG. 24

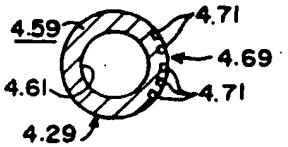


FIG. 26

FIG. 25

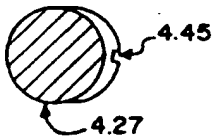


FIG. 27

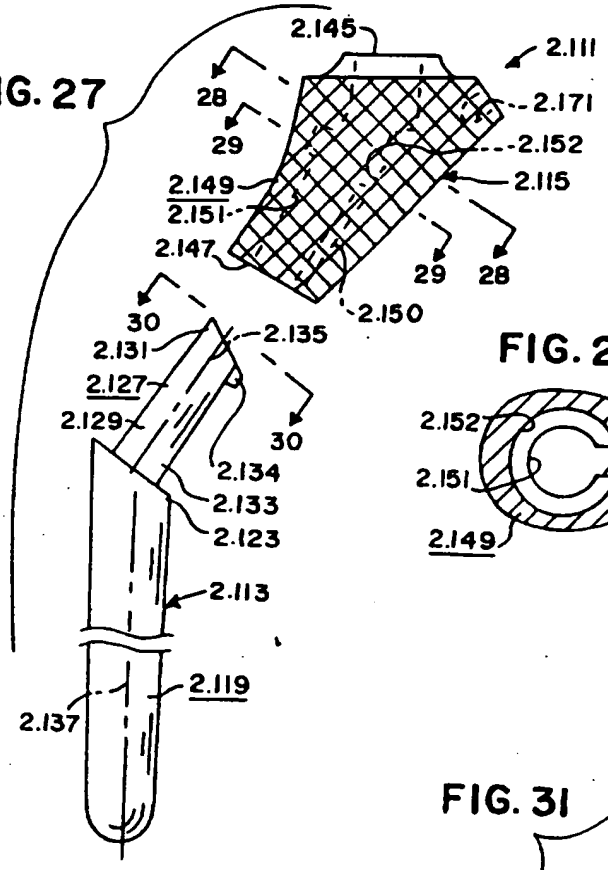


FIG. 28

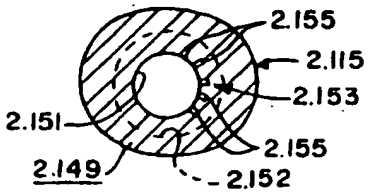


FIG. 29

FIG. 30

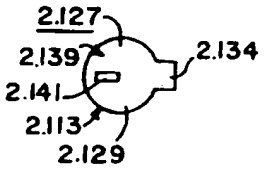


FIG. 31

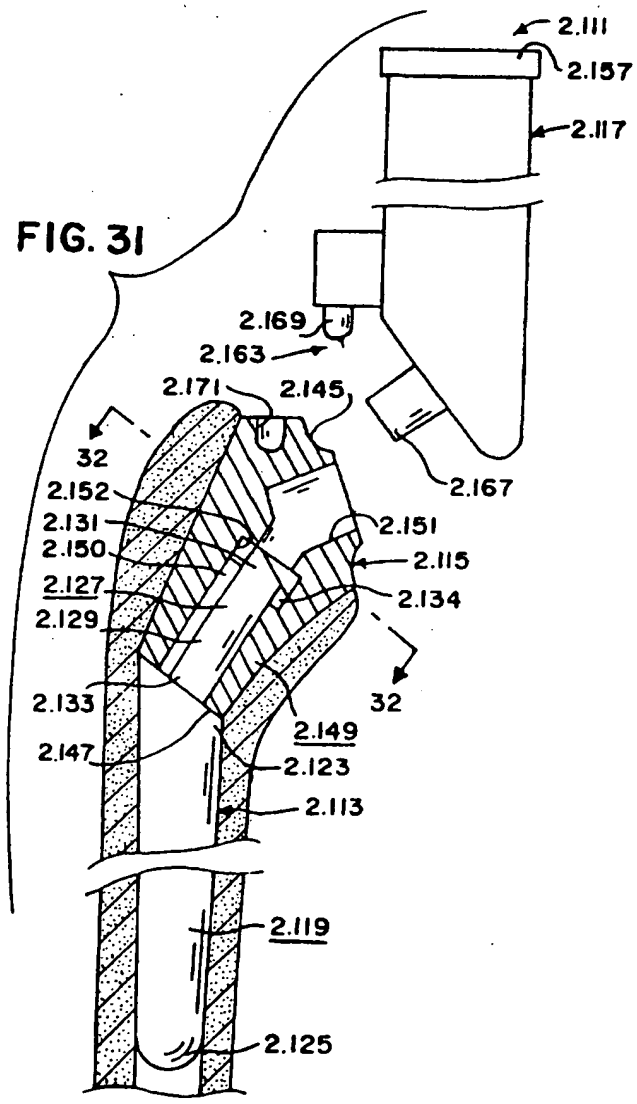
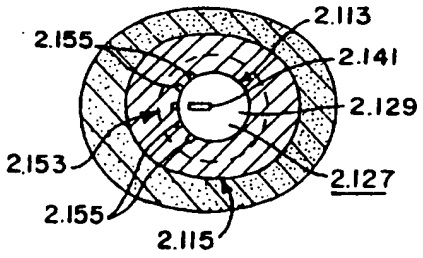


FIG. 32



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/14035

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61B 17/10; A61F 2/40
US CL :606/79; 623/19
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 623/18, 19, 22, 66; 606/79

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,358,526 (TORNIER) 25 October 1994, see entire document.	1-3, 9 --- 4-8, 10
X	US, A, 5,342,363 (RICHELSOPH) 30 August 1994, see entire document.	11, 12
X	US, A, 5,169,401 (LESTER ET AL.) 08 December 1992, see entire document.	11, 12
X --- Y	US, A, 5,261,915 (DURLACHER et al.) 16 November 1993, see entire document.	11, 12 --- 13, 14, 18
Y	US, A, 5,002,581 (PAXSON) 26 March 1991, see entire document.	1-10, 11, 13, 14, 18

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 FEBRUARY 1996	27 MAR 1996

Name and mailing address of the ISA/US	Authorized officer
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Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/14035

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,179,758 (GRISTINA) 25 December 1979, see entire document.	6-8